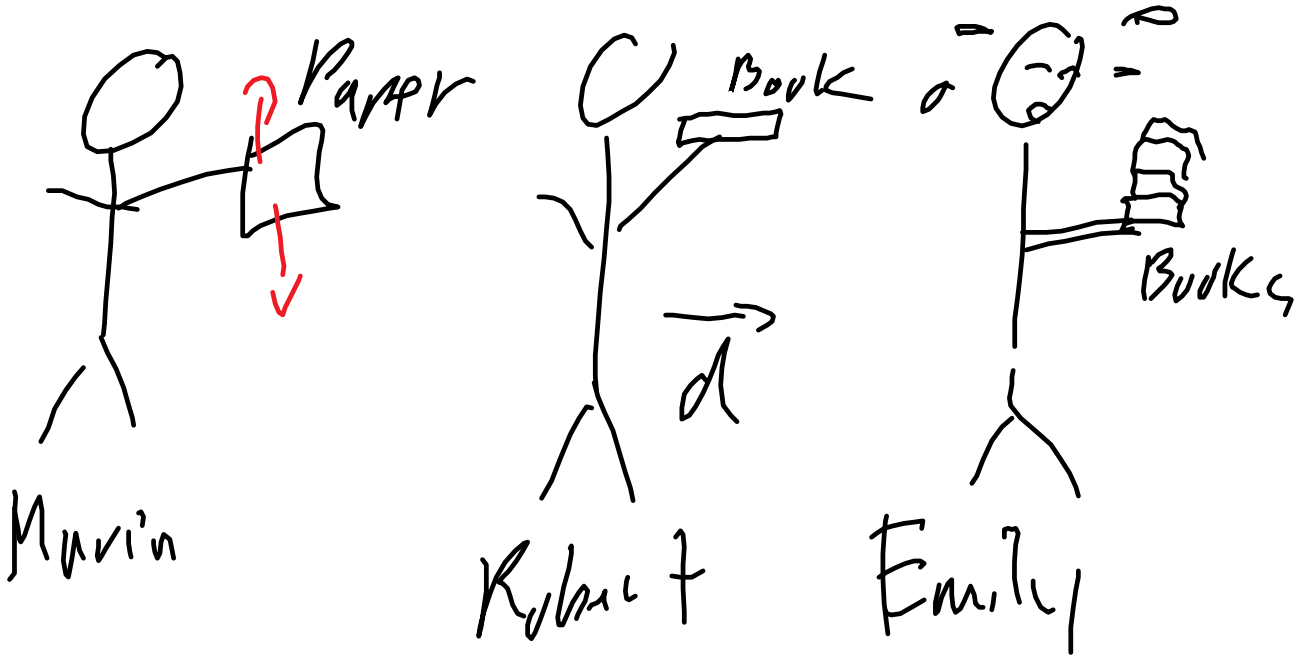
Work and Power

Demonstration:
Maria - lifting a piece of paper
Robert walking while holding a book
Emily holding a pile of books

Who is doing more work?



Isaac - why is Emily doing the most work?
The mass of the books has a strong force of gravity $F_g = mg$ so she is using the most force.

Luna - Robert is doing the most work because he is walking and the book is pushing. You need force to walk.

Mingquan - Why is Maria doing the most work?

Because the paper is moving in the direction of force.

Define work:

Work is measure of energy transfer that occurs when an object is moved over a distance by an external force with a component in the direction of motion (Google through Maria)

2 separate ideas - work as a change in energy and work as a force acting through a distance.

So Maria is applying a force in the direction of motion, so she is doing more force by that definition.

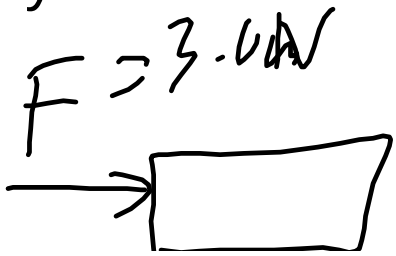
$W=Fd$ where F and d are in the same direction.

Work is a scalar - even though force and displacement are vectors, work has no direction but is can be negative, if force is opposite displacement.

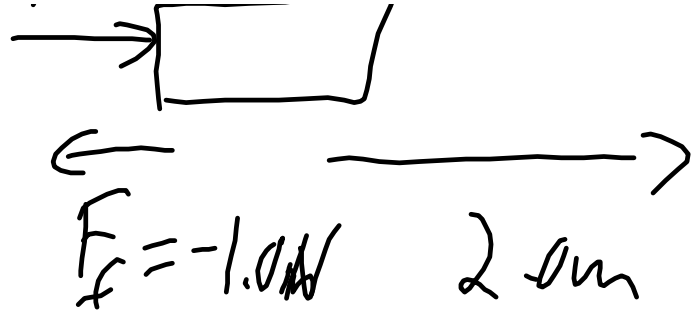
units of work are Joule, J=Nm

eg. You push on a wooden block sideways with 3.0 N of force over 2.0 m. If friction is 1.0N, how much work is done by

a) you
b) friction
c) the net force
d) gravity



c) the net force
d) gravity
e) normal force



a) $W = F \cdot d = 3.0N \times 2.0m$
$= \boxed{6.0J}$

b) $W = F \cdot d = -1.0N \times 2.0m$
$= \boxed{-2.0J}$

c) $F_{net} = 3.0N - 1.0N = 2.0N$

$W_{net} = F_{net} d = 2.0N \times 2.0m$
$= \boxed{4.0J}$

d and e $W = 0$

displacement is not in the direction of force so no work is done by gravity or normal force.

Power, P (lower case p is momentum)

is the rate of doing work or the rate of change in energy

P=W/t or ΔEnergy/t

units: Watts, W=J/s (another common unit is horsepower, hp=746W)

eg. A 60.0 kg student runs up 25 stairs, each 15cm high, in 5.0 s. How much work is done against gravity? What is the minimum power used by the student?
W=Fd = mgd = 60kg x 9.8N/kg x 25x 0.15m
W = 60x9.8x25x0.15=2,205.0 J = 2.2 kJ (2 sfs)
P=W/t = 2205/5=441 = 441 W = 0.44 kW
441/746=0.5912 = 0.59 horsepower

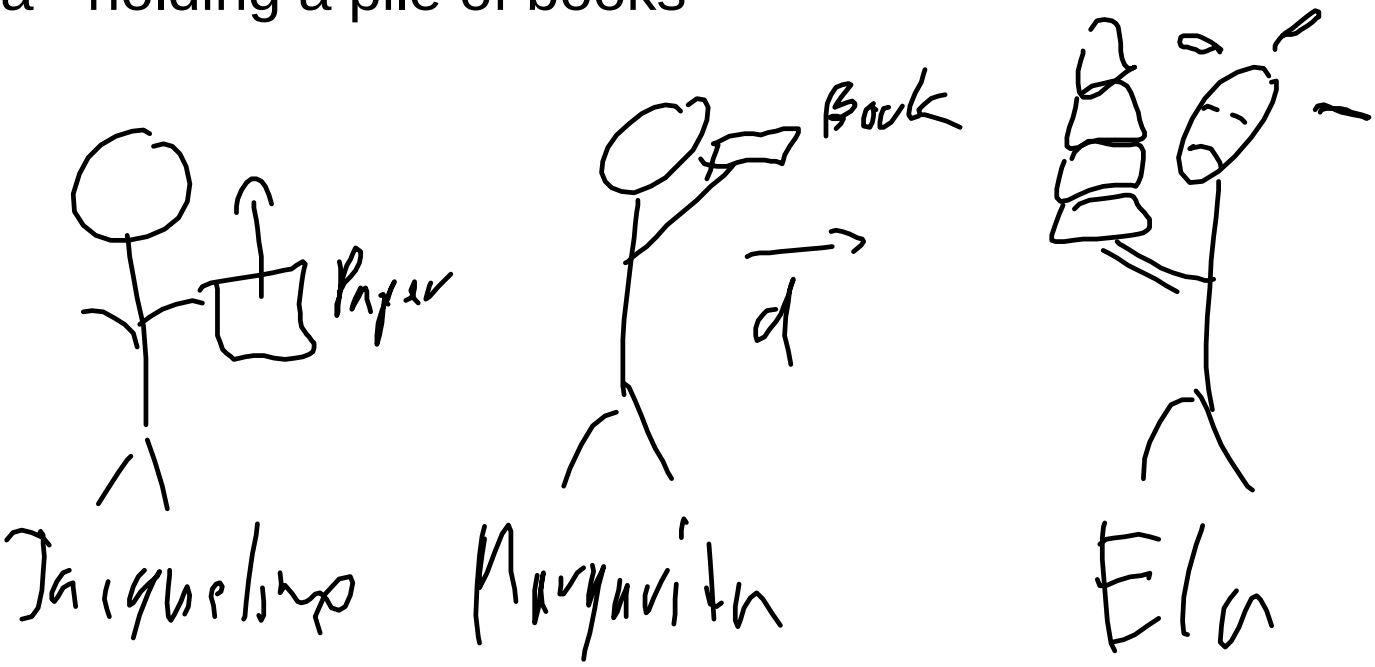
Assignment: p199 Q1-4 and run up stairs, calculate your horsepower.

Block 2-4

work and Power

Who is doing more work?
Jacqueline - lifting a piece of paper

Margarita - walking while holding a book
Ela - holding a pile of books



Brandon- Ela is doing more work because: when you are carrying lots of books, the mass is large, force of gravity is therefore large $F_g = mg$ so more work is required,
Michael - body is working hard to hold still

No one thinks Margarita does work.

Helen - Lifting paper is hard, you can get a paper cut.

Helen is right! (What???)

Why? because motion is part of the physics definition of work.

Google work - physics via Michael

Measure of energy transfer that occurs when an object is moved over a distance by an external force at least part of which is applied in the direction of the displacement.

2 big parts: energy transfer or change is part of work

force through a displacement

Ela was not moving, so she did no work (physical) though there was changes in energy.

Margarita had force and had displacement but did no work because the force was not in the direction of motion.

Jacqueline applied a force through a displacement, so she did work lifting the paper. but she did negative work lowering the paper, so the net work was zero.

If the force is opposite the displacement, the work is negative.

eg.
You push on a 5.0 kg block with 3.0N of force and slide it 2.0m from rest. If the

frictional force is 1.0N, how much work is done by

a) you - W=Fd = 3.0Nx2.0m = 6.0 J
b) friction - W=Fd = -1.0Nx2.0m = -2.0J
work is a scalar, so the negative doesn't indicate direction, it indicates a loss of energy.
c) net force $W_{net} = F_{net}xd$= (3.0N-1.0N)x2m = 4.0 J

d) gravity - W=0 F is not in the direction of motion
e) Normal force W=0 F is not in the direction of motion

W=Fd units: Joules, J=Nm (4.184J/cal)

Power P (momentum is lower case p)

P=W/t power is the rate of doing work

or the rate of change in energy

units: Watts, W = J/s (horsepower is an imperial unit for power, 1hp = 746W)

eg. A 60.0 kg student runs up 25 stairs, 15cm high in 5.0 s. What is the work done against gravity? What is the minimum

power of the student?

W = Fd = mgd = 60kgx9.8N/kgx(25x0.15m)
= 60x9.8x25x0.15=2,205.0 J = 2.2kJ

P = W/t = 2205/5=441 W = 441/746=
0.5912 = 0.59hp

p199 Q1-4 - run up stairs (carefully) and calculate your power

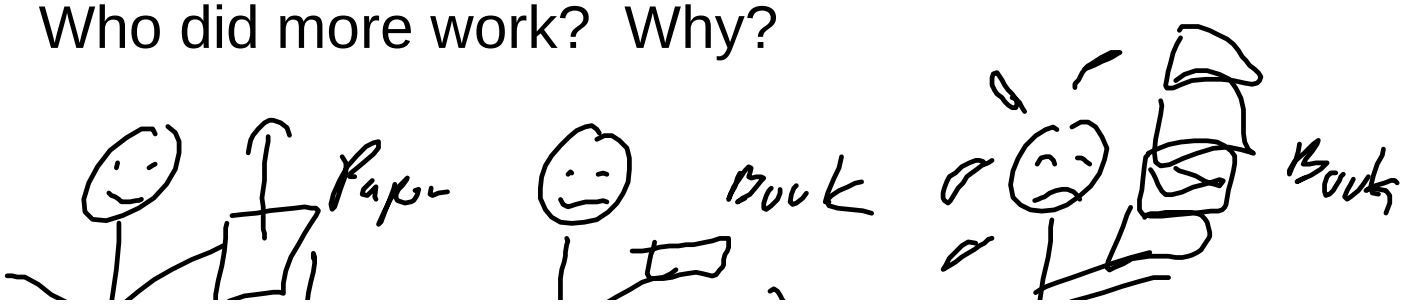
Block 2-4

Work and Power

3 volunteers:

Roberta - lifted a piece of paper
Darren - walked while holding a book
Harry - held a stack of books motionless

Who did more work? Why?



Justin thinks Darren did the most work because he had to move his body.

Harry thinks Harry did the most work because it was tiring to hold the books motionless.

No one thinks Roberta did the most work.

How do we decide? Check a definition of work.

definition:

Every day language, work is your job - google:
Manveer - activity involving mental or physcal effort done in order to acheive a purpose or result.

What if you google, work - physics

Ray - the exertion of force overcoming resistance over a displacement or producing change in energy.

2 things:
W=Fd if the force is in the direction of the displacement.
Units: Joule, J=Nm
work is a change in energy

So, Harry isn't doing physics work, because the force is not acting over a displacement.

Darren isn't doing work because the force on the book is up, not in the direction of his displacement.

Roberta is doing work on the paper lifting it up, W=Fd but she does negative work lowering the paper down - net work =0.

You guys didn't do work.

eg. You push a 5.0kg block with 3.0N of force sideways on a table over 2.0m. If the force of friction is 1.0N, how much work is done by

a) you W=Fd = 3.0N x 2.0m = 6.0J
b) friction W = Fd = -1.0Nx2.0m = -2.0 J

Work is a scalar - it has no direction. So what does the negative sign mean? It means a loss of energy.

c) net force W=Fd = (3.0N-1.0N)x2.0m = 4.0J
d) gravity W=0 F is not in the direction of d

e) Normal force W=0 F is not in the direction of d

Power, P (momentum is lower case p)

power is the rate of doing work or the rate of change in energy

P=W/t or change in energy/time

units: Watt, W=J/s (imperial unit horsepower 1hp=746W)

eg. a 60.0 kg student runs up 25 stairs, 15 cm high each, in 5.0 s. What is the work done by the student against gravity? What is the power in Watts and horsepower?

p199 Q1-4
you will run the stairs carefully and get your power

W= Fd = mgd = 60kgx9.8N/kgx25x0.15m
60x9.8x25x0.15=2,205.0 J = 2.2kJ
P= W/t = 2205/5=441 W

441/746=0.5912 = 0.59hp